Adaptive Multimedia Access: From User Needs to Semantic Personalisation

Alyson Evans
Personalisation and Knowledge Lab
Motorola Ltd., Basingstoke, UK
alyson.evans@motorola.com

Miriam Fernández, David Vallet, Pablo Castells
Escuela Politécnica Superior
Universidad Autónoma de Madrid, Spain
{miriam.fernandez,david.vallet,pablo.castells}@uam.es

***Abstract*—We discuss the use of a reliable user requirements methodology for gathering essential data relating to user needs in advanced, personalised multimedia content applications. We revise the implications of these requirements in the development of advanced personalised searching and browsing tools aimed at assisting the end-consumer by complementing explicit user requests with implicit user preferences, to better meet individual user needs. We examine the important technical challenges such as representing conceptual-level user interests, and coping with the subtleties of user preferences, such as variability and heterogeneity, which we see as critical for the success of personalisation techniques. We consider the fact that personalisation is not always appropriate, and it is sometimes preferable to disable it to avoid obtrusiveness.**

I. Introduction

With the revolution in audio-visual content creation, recording, production, storage, display, transmission, broadcasting, and networking technologies, the turn of the new decade has brought an explosive growth of the world-wide body of media content in digital format, both in businesses and in the home. People have instant access to unprecedented inventories of media content just a few clicks away from their office, their living room, or in the palm of their hand. With so much available content, users would be helpless without the assistance of powerful searching and browsing tools to find their way through. The size and the pace of growth of this content corpora constitutes a permanent challenge for content retrieval technologies. Moreover, in environments lacking a global organisation, with decentralised content provision, dynamic networks, etc., query-based and browsing technologies often reach their limits. As content volume continues to grow, even search results and browsing structures eventually become unmanageable for the end-consumer.

Personalisation technologies have been identified as a key approach to face these challenges. Personalised multimedia access aims at enhancing the retrieval process by complementing explicit user requests with implicit user preferences, to better meet individual user needs. Automatic user modeling and personalisation has been a thriving area of research for nearly two decades, gaining significant presence in commercial applications around the mid-90's. However, the high demands of the emerging new-generation digital society bring new challenges that existing technologies cannot easily meet in a direct manner. In this paper we present and discuss some of the requirements that arise in this context, their implications, and some technical solutions.

II. Gathering User Requirements

Working with users to understand their requirements for finding content requires an interaction that engages them to use their imagination to envisage new possibilities. It is necessary to develop a line of thought with users that prompts them to open their minds and develop self awareness of what they currently do, as well as why they do it, in order to explore possibilities for new tools or features that can help them to achieve things that are currently only on their 'I wish' lists. As the amount of multimedia content available increases most people wish they could find what interests them much faster so personalisation becomes a key facilitator in helping people to find precisely what they are looking for. To illustrate the methodology that can be used to gather and then meet such user requirements this paper refers to the development of personalised functionality within two new applications still being researched – a digital photo management application (the aceMedia project) and a personalised news service. The analysis and discussion is nonetheless amenable to other application scenarios and use cases.

One tried and tested method for gathering user requirements is simply to begin with examining user's current activities in order to understand where current problems lie and to then develop a discussion towards what those users wish they could do. The key to success in using this method is in the questions that are used as well as the way they are used to enable the user to reflect and imagine. A semi-structured interview is useful as a broad framework of questions that can be established to guide the discussion. It is also important for the interviewer to be flexible in following what the user says so that all deeply held views are fully expressed. There are 3 important areas to cover in such interviews.

The first is the current habits of users with respect to an activity such as managing a personal photo collection or following the news. This is done to uncover what the user is currently trying to achieve – their goals and their motivations.

This research was supported by the European Commission under contract FP6-001765 aceMedia and the Spanish Ministry of Science and Education (TIN2005-06885). The expressed content is the view of the authors but not necessarily the view of the aceMedia project as a whole.

People who take photos and build up a collection do so because they want to capture moments in their lives that they can look back on and share with family and friends. People who follow the news have general interests in global and national events and personal interests in specific areas.

The second area of focus is on finding out if what people are currently trying to achieve could be made easier using new technology. At this stage it is useful for the interviewer to have in mind the kind of technologies that are available and to raise questions about what users currently find difficult to do. In managing a large digital collection of photos users find it difficult to decide quickly on subsets of photos to share with different groups of family and friends. In following the news users are currently faced with a lot of information from a variety of sources – the TV, the radio, newspapers and the internet and finding news that they are interested in from sources that they trust is time consuming.

Moving on from difficulties they face it is easy for the users to focus on the third important area and to start to talk about what they wish they could do if there were no limits to technology or cost. This line of questioning is aimed at identifying unmet needs that new technologies could meet. At this point most people are able to generate or recount new ideas that have been born out of the frustration and limitations associated with what they can currently do. Owners of large digital photo collections wish they could limit the results of a search to conform to their preferences. People who follow the news wish they could get rapid updates of information that is important to them e.g. stock market news and sports updates as an event is happening.

III. User Requirements

By using the methodology described above user requirements were gathered for two new applications that have personalisation as a priority to help manage the volume of content.

A. Digital Photo Management

From the interviews with users about managing a digital photo collection users concerns were focused on how to put together sub-sets of photos to share with different groups of friends and family and on how to manage the enormous number of items that could be retrieved from searching. In general users were interested in providing information to the application that it could use to help sort their collections, e.g.

R1. The photo management system should allow the user to indicate their preferences about their photos.

Some more challenging requirements that can only be met using advanced, semantically aware, personalisation techniques, are e.g.

R2. The photo management application should deliver search results in a ranked personal way.

R3. The photo management system should learn to anticipate the users' preferences.

R4. The photo management system should be able to take account of changing user interests so that content received from external searches is not too narrow.

B. Personalised News Service

People interviewed about a personalised news service were enthusiastic about the idea of combining general global and national news with news topics that are of specific interest to them. Their motivation to keep up with the news is 'to keep a finger on the pulse' and to know what is happening in the world. They want to reduce time spent sifting information for what is of interest and what is not. Some people have strong motivations to receive very specific news for reasons connected with their jobs or personal travel and to find out about issues that affect them personally.

People were able to name specific categories of news interest and they stated that they would expect to set up a list of preferences to direct the first stages of personalisation. All users mentioned high level categories and then lower level sub-categories. All of the people interviewed in this study indicated that they would need to go to the sub-category level in order to achieve an acceptable level of specificity about their choices to focus the information they would like to receive e.g. for financial news a user would want to specify a named company only; for weather a user would want to specify a region; for politics a user would want to identify a region or country. Some topics may need more levels of sub-categories e.g. sport can be broken into types of sport, then tournaments, events, and further down to the level of individual teams and players.

Users had different views on how much detail they would like to specify in an application. Some would be interested in providing a profile based on high level categories others were more interested in identifying specific areas within a category that they would be interested in. An application would need to be flexible enough to support these differences. Those who indicated they would value a highly personalised service also indicated that they would be willing to spend the time to set up a more detailed profile initially. Most users indicated that they would initially set up a profile and then go back and tweak it once they had experienced the service it provided for a time.

A number of requirements were gathered in this study that indicate what the users expect from the service and how they would like it to perform e.g.

R5. The news service should provide a way for the users to indicate their news topic preferences.

R6. The news service should include live and rapid updates for news like match scores for sports and share prices.

Some of the requirements mentioned by users are more difficult to address and pose challenges for the existing technology, calling for the research of new system capabilities to deal with the complexities of user preferences, such as:

R7. The news service should accommodate a change in a person's interests as experience in life and events occur that are relevant to them.

R8. The news service should allow users to define topics of interest precisely using levels of sub-categories.

R9. The news service should give users the option to prioritise their personal news categories.

R10. The news service should permit users to select the geo-

graphical areas for which they want general breaking news. This probably also applies to political news.

R11. The news service should allow users to set time parameters for news categories i.e. I want to receive this information over this time period e.g. for travel purposes

R12. The news service should monitor news consumption and learn more about users' preferences from items that are being consumed.

R13. The news service should allow the user to easily change their profile as their interests change and sometimes focus their attention on a specific thematic area for a limited time.

R14. The news service should allow users to indicate their membership of defined groups like age and ethnic group if they would like to.

IV. Addressing User Requirements for Personalised Content Retrieval

One of the functional areas where personalisation is perceived as most useful by users is that of content filtering, retrieval and delivery (see e.g. requirement R2 in the previous section). Users seem inclined to rely on personalised features when they need to save time, wish to spare efforts, have vague needs, have limited knowledge of what can be queried for, or are not aware of recent content updates (see R6). However, personalisation can be perceived as erratic and obtrusive by the user if not handled adequately. In this section we discuss some key issues and proposals towards powerful yet reliable personalisation techniques for content retrieval, namely, the representation of user preferences, its implications in the effectiveness of personalised retrieval, and the definition of finer criteria and control mechanisms to determine when, how, and to what extent personalisation should be applied.

A. Representation of Content Preference Semantics

Most personalised retrieval techniques (e.g. collaborative filtering) keep and process long records of accessed documents by each user, in order to infer potential preferences for new documents (e.g. by finding similarities between documents, or between users). The data handled by these techniques have been rather low-level and simple: document IDs, text keywords and topic categories at most [4][5]. The recent proposals and achievements towards the enrichment of multimedia content by formal, ontology-based, semantic descriptions open new opportunities for improvement in the personalisation field from a new, richer representational level [3][6]. We see the introduction of ontology-based technology in the area of personalisation as a promising research direction, albeit incipient [3]. Ontologies enable the formalisation of user preferences in a common underlying, interoperable representation, whereby user interests can be matched to content meaning at a higher level, suitable for conceptual reasoning [2][6].

An ontology-based representation is richer, more precise, less ambiguous than a keyword-based model. It provides an adequate grounding for the representation of coarse to fine-grained user interests (e.g. interest for individual items such as a sports team, an actor, a stock value) in a hierarchical way (see e.g. R8), and can be a key enabler to deal with the subtleties of user preferences, like the ones mentioned earlier in section in section III.B. An ontology provides further formal, computer-processable meaning on the concepts (who is coaching a team, an actor's filmography, financial data on a stock), and makes it available for the personalisation system to take advantage of. Moreover, an ontology-rooted vocabulary can be agreed and shared (or mapped) between different systems, or different modules of the same system, and therefore user preferences, represented this way, can be more easily shared by different players. For instance, a personalisation framework may share a domain ontology with a knowledge-based content analysis tool that extracts semantic metadata from a/v content, conforming to the ontology. On this basis, it is easier to build algorithms that match preference to content, through the common domain ontology.

The aceMedia project is an example where this approach has been followed [1]. Semantic user preferences are represented in the aceMedia personalisation system as a vector of weights (numbers from 0 to 1), representing the intensity of the user interest for each concept in a domain ontology [6] (thus meeting requirement R9). If an analysis tool identifies, for instance, a cat in a picture, and the user is known to like cats, the personalisation module finds how the user may like the picture by comparing the metadata of the picture, and the preferred concepts in the user profile. Based on preference weights, measures of user interest for content units can be computed, with which it is possible to discriminate, prioritize, filter and rank contents (a collection, a catalog section, a search result) in a personal way (as per R2).

Furthermore, ontology standards backed by international consortiums (such as the W3C), and the corresponding available processing tools, support inference mechanisms that can be used to further enhance personalisation, so that, for instance, a user interested in animals (superclass of cat) is also recommended pictures of cats. Inversely, a user interested in lizards, snakes, and chameleons can be inferred to be interested in reptiles with a certain confidence. Also, a user keen of Sicily can be assumed to like Palermo, through the transitive locatedIn relation (a useful feature for e.g. R10). In fact, it is even possible to express complex preferences based on generic conditions, such as "athletes that have won a gold medal in the Olympic Games".

B. When to Personalise and How Much

One of the common concern expressed by users regarding the automatic system adaptation to their profile is that personalisation is not desirable all the time. Indeed, if a user has a very clear and specific information need (e.g. get a copy of the "Matrix" movie), and a standard retrieval system is able to respond with the highest precision, personalisation would only get in the way of the user and the system. Even when this is not the case (e.g. vague user needs or unsuccessful system response), if an automatic user preference learning mechanism is being used (as R3, R7 and R12 suggest), the inherent ambiguity of user actions upon which the preferences are automatically inferred introduces a significant degree of

uncertainty in the system's assumptions about the user. Therefore, it is commonly agreed that the user should always have the means to turn personalisation on and off.

However, this does not need to be a binary decision, since personalisation admits different degrees on a continuous range. The user might be allowed to tune the level of personalisation as a free parameter e.g. using a slider. Alternatively, in order to relieve the user from the burden of this decision, a fixed moderate degree can be set by experimental tuning. But the same degree is not necessarily appropriate for all situations. A system that could decide by itself what amount of personalisation is appropriate in each case would greatly enhance reliability and user confidence.

As a general rule, the intensity of personalisation should increase with the amount of uncertainty in both user requests and system responses, and decrease with the amount of uncertainty in the user preferences stored in the system. Assessing (or even defining) such uncertainty with the information available in the system is a fairly difficult problem in general. One approach is to get explicit relevance feedback from the user, but it has been shown that it is possible to achieve a good approximation without any help from the user, and have personalisation automatically adjusted by the system, based on specificity indicators such as the length of user queries, number of conditions, specificity of query concepts, or the size and semantic heterogeneity of search results (see [2]). Here, the precision of ontology-driven semantics is key to enable a sharper analysis of the vagueness of queries and results within the system.

C. *Personalisation in Context*

Not only may user preferences be relevant or irrelevant as a whole, for a given user need at a specific point in an interactive session. User requirements show that human preferences are complex, variable and heterogeneous, and it should be further discriminated *which* preferences are relevant in each different context (see R4, R7, R13). For instance, if a user is consistently looking for some contents in the Formula 1 domain, it would not make much sense that the system prioritises some Formula 1 picture with a helicopter in the background just because the user happens to have a general interest for aircrafts. In other words, *in the context of* Formula 1, aircrafts are out of (or at least far from) context. Context is a difficult notion to grasp and capture in a software system, and the elements than can, and have been considered in the literature under the notion of context are manifold: user tasks and goals, computing platform, network conditions, social environment (R14), physical environment, location (R11), time (R10), noise, external events, text around a word, visual context of a graphic region, to mention a few.

One useful notion we are developing in aceMedia is that of *semantic runtime context*, which we define as the background themes under which user activities occur within a given unit of time. Using this notion, and beyond the proposals put forward in the previous section, a finer, qualitative, context-sensitive activation of user preferences can be defined. Instead of a uniform level of personalisation, user interests related to the context are prioritised, discarding the preferences that are out of focus. The problems to be addressed include how to represent such context and determine it at runtime, and how the activation of user preferences should be related to it, predicting the drift of user interests over time. Our initial approach is based on a concept-oriented context representation, and the definition of distance measures between context and preferences as the basis for the dynamic selection of relevant preferences.

When the system perspective is widened to take in contextual aspects of the user, it is often relevant, as indicated by user requirements (e.g. R14 and section III.A), to consider the case where the user does not work in isolation. Indeed, the proliferation of virtual communities, computer-supported social networks, and collective interaction (e.g. several users in front of a STB), call for further research on group modeling, opening new problems and complexities. A variety of group-based personalisation functionalities can be enabled by combining, comparing, or merging preferences from different users, where the expressive power and inference capabilities supported by ontology-based technologies can act as a fundamental piece towards higher levels of abstraction.

V. CONCLUSION

Personalisation is a complex feature that has to be carefully handled along the whole software development cycle: from user requirements analysis, to system requirements definition, definition of models, design of algorithms, architecture design, implementation and evaluation. Failure to adequately address the fine aspects involved in any of these tasks can easily render useless a personalisation system. In this paper we have focused on issues that are critical for the success of personalisation from both user and system perspectives. We have presented our findings in user requirement studies conducted in two projects, and we have proposed and discussed some advanced technical approaches towards some of the most complex to meet requirements. A common underlying consideration in our technical discussion is the use of ontologies as a key tool for moving beyond current state of the art in the area of personalisation.

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